STANDARD FOR CONDUIT OUTLET PROTECTION

Definition

Conduit Outlet Protection consists of an erosion resistant section between a conduit outlet and a stable downstream channel.

Purpose

To provide a stable area at the outlet of a conduit in which the exit velocity from the conduit is reduced to a velocity consistent with a stable condition in the downstream channel.

Conditions Where Practice Applies

This practice applies to all conduit outlets. Conduit outlet protection is not needed if the design flow is not constricted by the conduit in the waterway or stream (top width in culvert equals normal flow top width in stream). Under this condition, transition areas such as at bridge or culvert abutments shall be armored up and downstream in accordance with the riprap standard. This includes areas in the immediate vicinity of the culvert which may be disturbed in order to facilitate the culvert installation.

Water Quality Enhancement

The use of this standard will protect the area immediately downstream of a conduit outlet from localized erosion in the form of scour, which is a common source of sediment in lakes and streams.

Design Criteria

Determination of Needs

The need for conduit outlet protection shall be determined by comparing the allowable velocity for the soil onto which the conduit is discharging to the velocity in the conduit. The allowable velocity for the soil shall be that given in Table 12-1, pg. 12-2. The velocity in the conduit shall be that which occurs during passage of the conduit design storm or the 25-year frequency storm, whichever is greater. When the velocity in the conduit exceeds the allowable velocity for the soil, conduit outlet protection will be used.

TABLE 12-1 ALLOWABLE VELOCITIES FOR VARIOUS SOILS

SOIL TEXTURE	ALLOWABLE VELOCITY (ft./sec.)
Sand	1.8
Sandy loam	2.5
Silt loam (also high lime clay), loam	3.0
Sandy clay loam	3.5
Clay loam	4.0
Clay, fine gravel, graded loam to gravel	5.0
Cobbles	5.5
Shale (non-weathered)	6.0

A. Horizontal Riprap Apron (fig. 12-1, 12-2)

Apron Dimensions

1. The length of the apron, La, shall be determined from the formula:

TW < ½ D_o $$La = 1.8\left(\frac{q}{Do^{1.5}}\right) + 7$$

where $q = \frac{Q}{Wo}$

TW ≥ ½ D_o $$La = 3Do\left(\frac{q}{Do^{1.5}}\right)$$

Where D_o is the maximum inside culvert height in feet, W_o is the maximum inside culvert width in feet, q is the unit discharge, = Q/W_o in cfs per foot for the conduit design storm or the 25 year storm, whichever is greater.

2. Where there is no well-defined channel immediately downstream of the apron, the width, W, of the outlet end of the apron shall be as follows:

For tailwater elevation greater than or equal to the elevation of the center of the pipe,

Wa = 3 Wo + 0.4 La

For tailwater elevation less than the elevation of the center of the pipe,

Wa = 3 Wo + La

Where L_a is the length of the apron determined from the formula and W_o is the culvert width.

The width of the apron at the culvert outlet shall be at least 3 times the culvert width.

3. Where there is a well-defined channel downstream of the apron, the bottom width of the apron shall be at least equal to the bottom width of the channel; and the structural lining shall extend at least one foot above the tailwater elevation but no lower than two-thirds of the vertical conduit dimension above the conduit invert.

4. The side slopes shall be 2:1 or flatter.

5. The bottom grade shall be 0.0% (level).

6. There shall be no over fall at the end of the apron or at the end of the culvert.

B. Riprap

1. The median stone diameter, D_{50}, in feet, shall be determined from the formula:

For Horizontal Apron: $d_{50} = \frac{0.02}{Tw} q^{1.33}$ where $q = \frac{Q}{Wo}$

For areas where Tw cannot be computed, use Tw = 0.2 D_o

Where q and D_o are as defined under apron dimensions and T_W is tailwater depth above the invert of culvert in feet.

<u>Preformed Scour Hole</u>

Performed scour holes may be utilized, as depicted in Figure 12-3 where conditions dictate the impractical use of flat aprons. The median stone diameter, D_{50}, in feet, shall be determined from the following formulas:

where Y = ½ D_o $d_{50} = \frac{0.0125}{Tw} q^{1.33}$

where Y = D_o $d_{50} = \frac{0.0082}{Tw} q^{1.33}$

Y = depth of scour hole below culvert invert and $q = \frac{Q}{Wo}$

The use of scour holes shall comply with county or local ordinances which would restrict the use of such devices due to possible problems with mosquito breeding.

Conduit Outlet Protection Design for Discharge into Detention Basins

Design of the median stone size for pipes discharging into a basin shall be based on one of the following methods:

1. Q shall be the 25 year storm discharge and Tw shall equal the 2 year storm elevation in the basin.

2. Analyze the hydraulic characteristics of the basin for the design storm to determine the combination of conduit discharge and tailwater that results in the largest required D_{50} stone size.

Downstream Protection

The conduit discharge shall not cause erosion in the downstream channel or aggravate conditions in the downstream channel. The designer shall furnish calculations to show that the conditions downstream will not be degraded as a result of the proposed construction (See Standard for Off-Site Stability, pg. 21-1)

Riprap Requirements

1. Fifty percent by weight of the riprap mixture shall be smaller than the median size stone designated as D_{50}. The largest stone size in the mixture shall be 1.5 times the D_{50} size. The riprap shall be reasonably well graded.

2. The thickness of riprap lining, filter and quality shall meet the requirements in the Riprap Standard pg. 23-2 & 23-3.

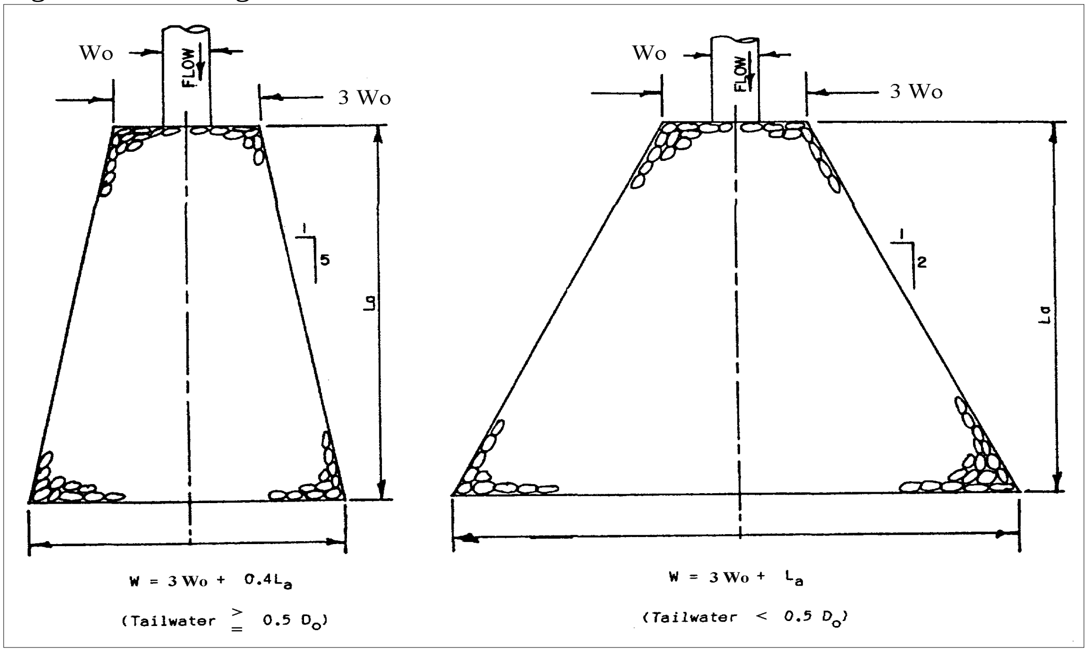
3. Properly designed concrete paving may be substituted for riprap.

4. Plastic-coated wire mesh stone-filled baskets or mattresses or concrete revetment blocks may be substituted for riprap if the D_{50} size calculated above is less than or equal to the thickness of the wire mesh structures or concrete revetment blocks. Design life of the wire mesh structures is estimated to be ten (10) years (minimum). Wire mesh baskets shall be filled with 4" to 7" angular shaped rock. For wire mesh “mattress” structures 3" to 4" stone may be used provided the mesh opening is small enough to contain the stone. Smaller stone will provide more stone “layers” in the mattress where larger stone would not sufficiently fill the structure’s void space.

Installation Requirements

1. No bends or curves at the intersection of the conduit and apron or scour hole will be permitted.
2. There shall be no over fall from the end of the apron to the receiving channel.

Figure 12-1 Configuration of Conduit Outlet Protection

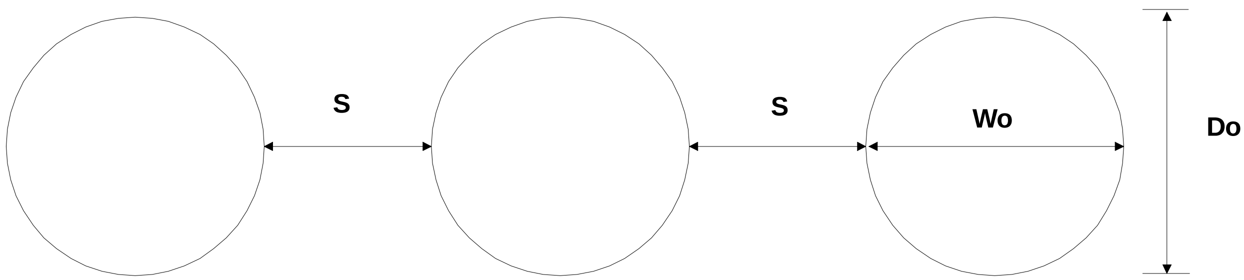


References

Fletcher, B. P. and Grace, J. S. Jr., Practical Guidance For Estimating And Controlling Erosion at Culvert Outlets, 1972, Corps of Engineers Research Report H-72-5, Waterways Experimentation Station, Vicksburg, Mississippi

Figure 12-2 Guidance for Multiple Culvert Outlets

All Culverts Same Diameter
Discharging Same Q



For $S < \frac{1}{4} W_o$ Size Riprap & Length for 1 pipe.
Width shall accommodate all culverts

For $S \geq \frac{1}{4} W_o$ Size Riprap & Length for 1 pipe and
increase values by 25 %

For culverts of varying diameters or discharge check riprap size and apron length for each. Use the largest values. Increase length and riprap values by 25% if spacing is greater than ¼ W_o. Width shall accommodate all culverts.

Figure 12-3 Configuration of Preformed Scour Hole